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THERMOCHEMICAL TREATMENT EFFECT ON HEAT-RESISTANCE AND FRACTURING OF FLOAT-GLASS

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The results of studies of the heat-resistance of float-glass samples with modified surfaces are presented. The character of the fracturing of the glass during tests is shown. It is determined that thermochemical treatment of float-glass surfaces with certain reagents increases the heat-resistance and considerably decreases its variance.

Key words: heat-resistance of glass, heat-absorbing glass, modified surfaces, character of the fracturing of glass.

Silicate sheet glass is widely used to manufacture machines and instruments, in construction, and in the aviation, nuclear, electronic and other sectors of industry as a construction material for load-bearing structures [1].

The high working properties required of sheet glass make it necessary to perform research on improving its strength. The strength characteristics of sheet glass are determined mainly by the state of its surface. The technologies making it possible to create a new surface layer without any changes to the composition and structure of the material also make it possible to improve the properties of glass, such as strength, hardness, heat-resistance, chemical stability, light transmission and others [2].

An important characteristic of heat-absorbing sheet glass is the heat-resistance, i.e., the ability to withstand sharp temperatures drops without fracturing.

We have performed experimental work on modifying the surface of samples of float-glass in order to study their heat-resistance and fracturing.

The work on thermochemical modification was performed on samples of heat-absorbing glass developed on the commercial float-line at the Saratov Institute of Glass.

The heat-resistance of glass was determined using a procedure developed on the basis of GOST 11103–85 and making it possible to obtain reliable data on 100 × 100 mm samples [3].

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The results of the measurements of the heat-resistance of glass samples after thermochemical treatment are presented in Table 1 and Fig. 1.

The average values of the heat-resistance for each type of reagent were obtained for samples cut along the width of a float-ribbon (16 pieces). The heat-resistance of samples of the initial glass (average value 143°C) was measured in order to compare the data obtain.

It is evident from Fig. 1 that the heat-resistance of the glass increased in practically all cases where modifying reagents were used. The highest heat-resistance was attained by thermochemical treatment of glass samples with a solu-

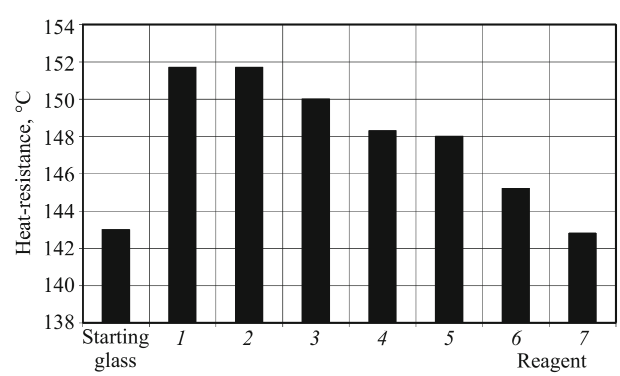


Fig. 1. Dependence of the heat-resistance of glass on the form of the modifying reagent: *1*) boric acid solution; *2*) ammonium sulfate solution; *3*) ammonium sulfate powder; *4*) potassium phosphate powder; *5*) PMS-200A solution; *6*) CCC solution; *7*) potassium phosphate solution.

TABLE 1. Heat-Resistance of Glass Samples Heat-Treated with Different Reagents

Reagent	Average heat-resistance Q_{av}, °C	Standard deviation δ, °C	Variance d	Variation coefficient γ, %
Ammonium sulfate powder $(NH_4)_2SO_4$	150.0	0.00	0.00	0.00
Polymethyl siloxane solution PMS-200A	148.0	0.00	0.00	0.00
Boric acid solution H_3BO_3	152.0	2.89	8.33	1.90
Ammonium sulfate solution $(NH_4)SO_4$	152.0	2.89	8.33	1.90
Potassium phosphate powder $K_2HPO_4 \cdot 3H_2O$	148.0	2.50	6.25	1.69
Potassium phosphate solution $K_2HPO_4 \cdot 3H_2O$	143.0	8.50	72.25	5.95
CCC* solution	145.0	3.83	14.70	2.64
No reagent (starting)	143.0	5.39	29.06	3.76

* CCC) cold coating compositions (TU 233229-004-49546302–99).

tion of boric acid and with ammonium sulfate (in form of a solution and powder).

In addition, as Table 1 shows, after thermochemical treatment of glass samples with ammonium sulfate powder and PMS-200A polymethyl siloxane solution the variance of the heat-resistance became zero. This equalization of the values of the heat-resistance of the glass is especially important considering the difference between the minimum and maximum values of the heat-resistance over the width of the float-ribbon (30 – 35°C) [4].

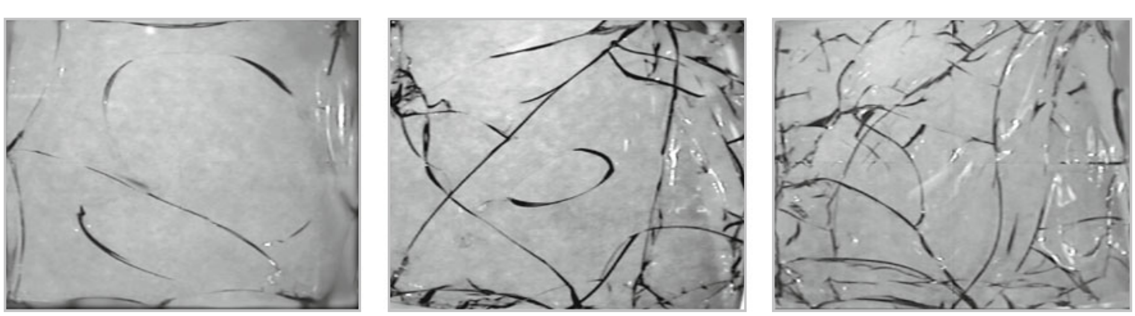
Equipping a microscope with a video system to outputting an image to a computer monitor made it possible to study crack formation and to obtain photographs of the glass samples tested. The tests showed that the minimum heat-resistance is characteristic for samples which show edge chipping produced by a cutter roller. When the heat-resistance of samples is measured individual filamentary cracks emanating from the cleavage face are formed. In addition fracturing of this type was observed for all samples having edge defects. This confirms that the edge quality affects the heat-resistance of glass and that the edges must be heat-insulated when measuring the heat-resistance.

Figure 2 shows that fracturing character for samples of the starting (no modifying coating) glass with minimum, average and maximum heat-resistance. It is clearly seen that the number of cracks formed during fracturing increases with the heat-resistance of the glass. When the maximum values of the heat-resistance are reached the surface of the sample becomes covered with numerous fine cracks, which are due to the stresses between the exterior and interior layers of the glass.

This regular behavior is graphic confirmation of the published data on the direct relation between the heat-resistance and mechanical strength of sheet glass. The stronger the glass, the higher its heat resistance is and the more cracks cover the glass as it fractures. Since the strength of the interior parts of the glass is much higher than that of the surface, the heat-resistance of the glass is due mainly to the strength of the surface, i.e., the strength of the weakest spots in glass articles [5].

Figure 3 displays a comparative picture of the fracturing of the starting samples and samples with modified surfaces with the same high heat-resistance (150°C).

The entire sample of the starting glass is covered with a characteristic network of fine cracks (Fig. 3*a*), while the fracturing of a sample with modified surfaces has changed. Only isolated cracks emanating from the edge are seen on the surface; damage in the form of a network of arc-shaped cracks is observed in the interior of the glass (Fig. 3*b*).



a *b* *c*

Fig. 2. Character of the fracturing of heat-absorbing float-glass samples with different heat-resistance: *a*) sample with the lowest heat-resistance (121°C); *b*) sample with average heat-resistance (143°C); *c*) sample with the highest heat-resistance (150°C).

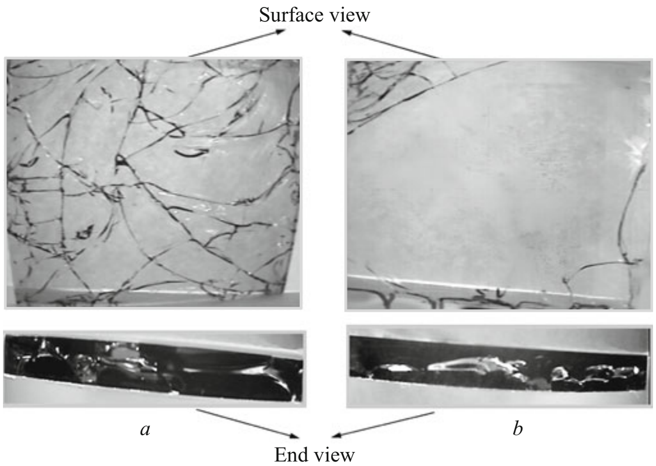


Fig. 3. Character of the fracturing of heat-absorbing float-glass samples with the highest heat-resistance (150°C): *a*) sample of the starting glass; *b*) sample of glass with modified surfaces.

It should be noted that the fracturing of samples with modified surfaces (on contact with water) was accompanied by loud crackling characteristic for samples with high heat-resistance. However, the damage to the surface of the glass was negligible, in contrast to the interior layers. It can be concluded that thermochemical heat treatment of glass samples strengthened their surfaces. The results of the tests performed on the samples treated with boric acid and ammonium sulfate confirm this result. For centro-symmetric bending the average strength increased by a factor ~2.

In summary, as a result of studies of samples of float-glass subjected to thermochemical treatment reagents were found that increase the heat-resistance of glass to maximum values (when the heat-resistance of the near-surface layers is higher than that of interior layers) and eliminate the heat-resistance differential over the width of a float-ribbon.

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